Given the following, determine size of the sub-fields (in bits) in the address for direct mapping, associative and set associative mapping cache schemes.

- We have 256 MB main memory and 1MB cache memory.
- The block size is 128 bytes.
- There are 8 blocks in cache set.

Number of tags for Direct Mapping $= \dfrac{\text{main memory size}}{\text{cache memory size}}$

$$= \frac{2^8 \times 2^{20}}{2^{20}} = 2^8$$

Number of blocks present in cache

$$= \frac{\text{cache memory size}}{\text{block size}} = \frac{2^{20}}{2^7} = 2^{13}$$

The block size is 128 bytes $= 2^7$

No. of Tags present for set associative mapping $= \dfrac{\text{main memory size}}{\dfrac{\text{cache memory size}}{\text{No.of way}}}$

$$= \frac{2^8 \times 2^{20} \times 2^3}{2^{20}} = 2^{11}$$

No. of set present in cache

$$= \frac{\text{No. of blocks present in cache}}{\text{No.of way}}$$

$= 2^{13} / 2^3 = 2^{10}$

Direct Mapping

Memory address 28 bit

Tag	Block	Word
8 bit	13 bit	7 bit

Associative Mapping

Memory address 28 bit

Tag	Word
21 bit	7 bit

8 way set Associative Mapping

Memory address 28 bit

Tag	Set	Word
11 bit	10 bit	7 bit

Given the following, determine size of the sub-fields (in bits) in the address for direct mapping, associative and set associative mapping cache schemes where processor address is 32 bit.

We have 2MB cache memory.

The block size is 64 bytes.

There are 4 blocks in cache set.

Write-through and Write-back method

Write-through :

- The simplest and most commonly used procedure.
- During write operation when the cache location is updated at the same time main memory also updated.
- main memory always contains the same data as the cache.

Advantage: This characteristic is important in systems with Direct Memory Access (DMA) transfers. It ensures that the data residing in main memory are valid and DMA would transfer the most recent updated data.

Disadvantage: For every modification of cache, main memory access required.

write-back:

- In this method only the cache location is updated during a write operation.
- The location is then marked by a flag or modified bit so that later when the word is removed from the cache it is copied into main memory.

Advantage: During the time a word resides in the cache, it may be updated several times. For this reason repeatedly memory access is not required for a word modification.

Disadvantage:

Valid bit

- After initialization the cache is considered to be empty, but in effect it contains some non valid data.
- One extra valid bit include with each entry in cache to indicate whether or not the entry contains valid data.
- If valid bit is 1 that means the cache entry is valid and 0 means entry is not valid
- The cache is initialized by clearing all the valid bits to 0.
- The valid bit of a particular cache word is set to 1 the first time this word is loaded from main memory

An 8 KB direct-mapped write-back cache is organized as multiple blocks, each size of 32 bytes. The processor generates 32-bit addresses. The cache controller contains the tag information for each cache block comprising of the following.

1 valid bit

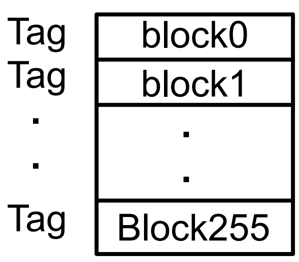
1 modified bit

As many bits as the minimum needed to identify the memory block mapped in the cache.

What is the total size of memory needed at the cache controller to store tags for the cache?

Number of blocks present in cache

$$= \frac{\text{cache memory size}}{\text{block size}} = \frac{2^3 \times 2^{10}}{2^5} = 2^8 = 256$$



Cache

Number of tags $= \frac{\text{main memory size}}{\text{cache memory size}}$

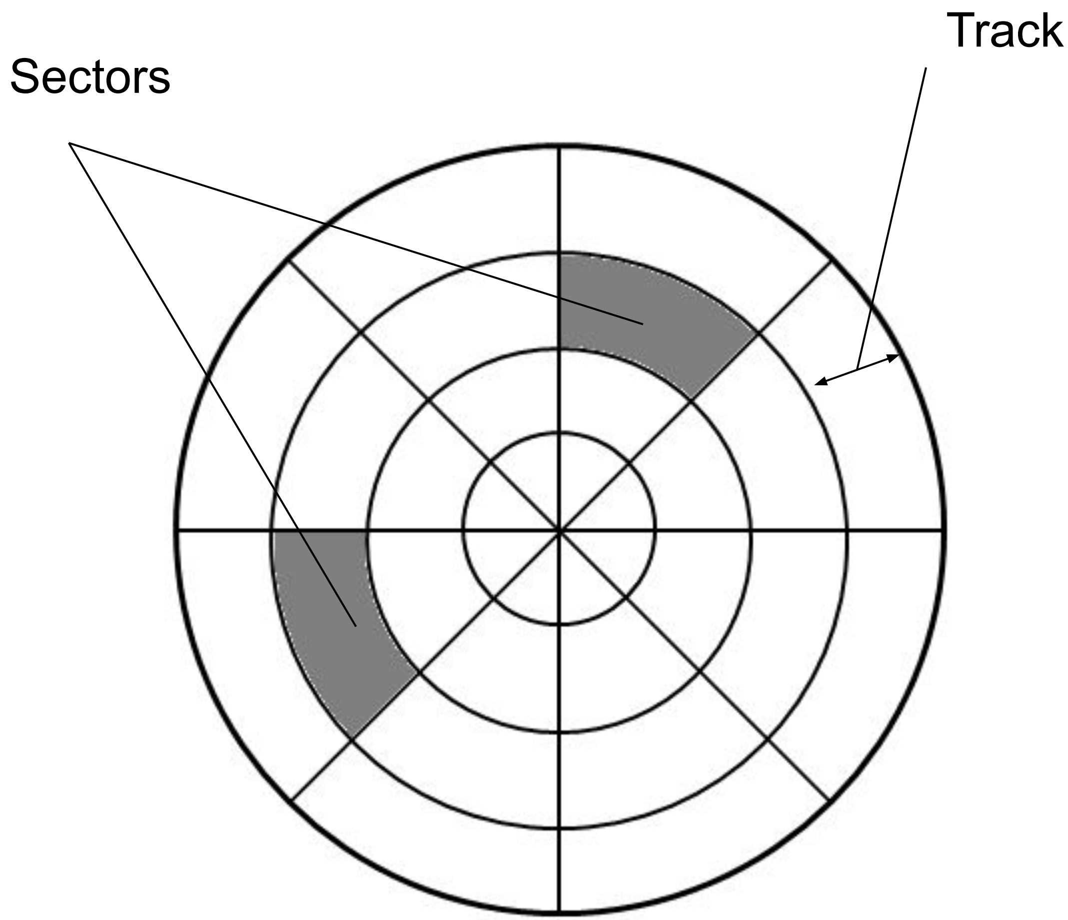
$$= \frac{2^{32}}{2^3 \times 2^{10}} = 2^{19}$$

So, a tag entry size = 19 + 1(valid bit) + 1(modified bit) = 21 bits.

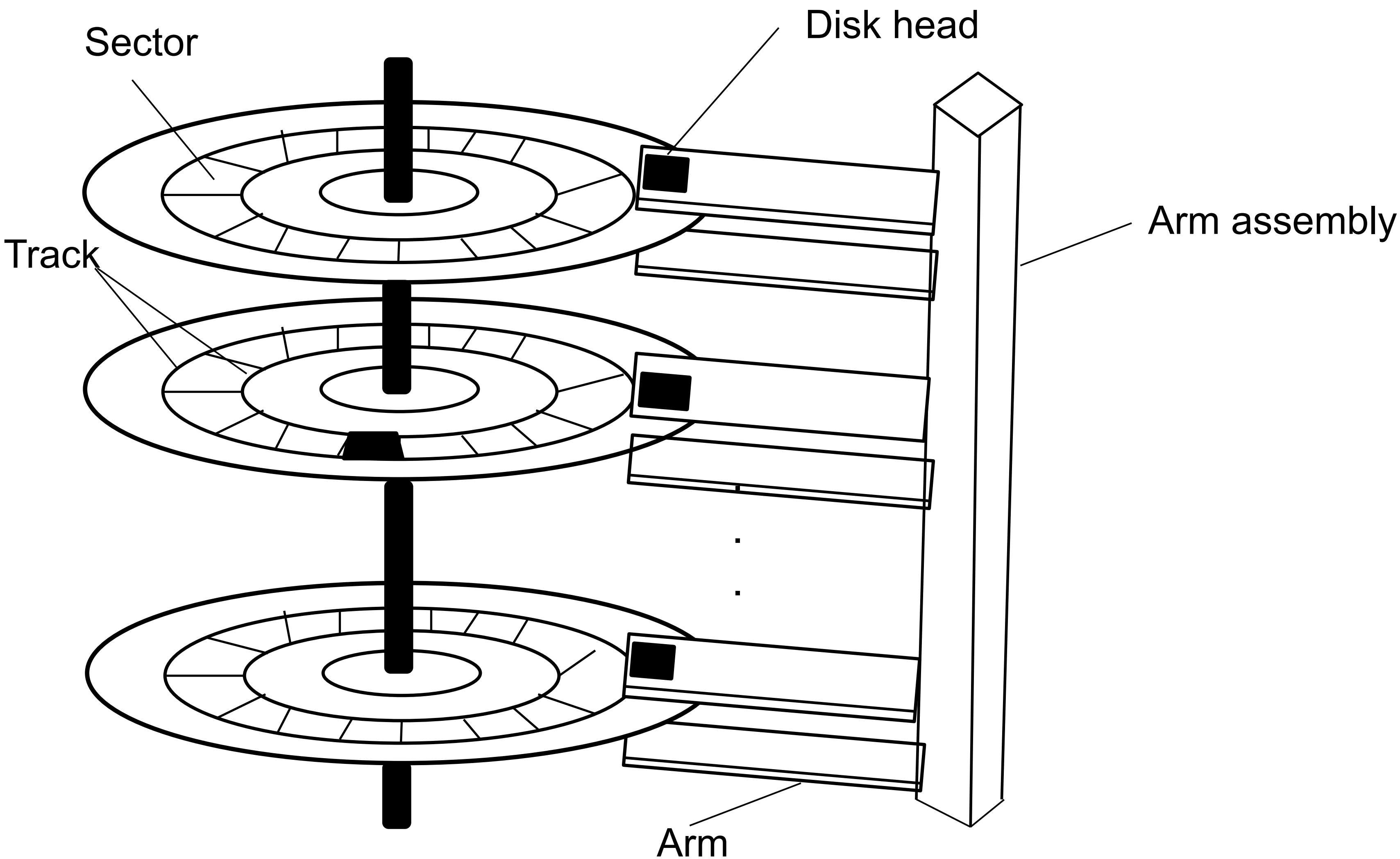
Total size of tag = 21 × Number of cache blocks

= 21 × 256 bits

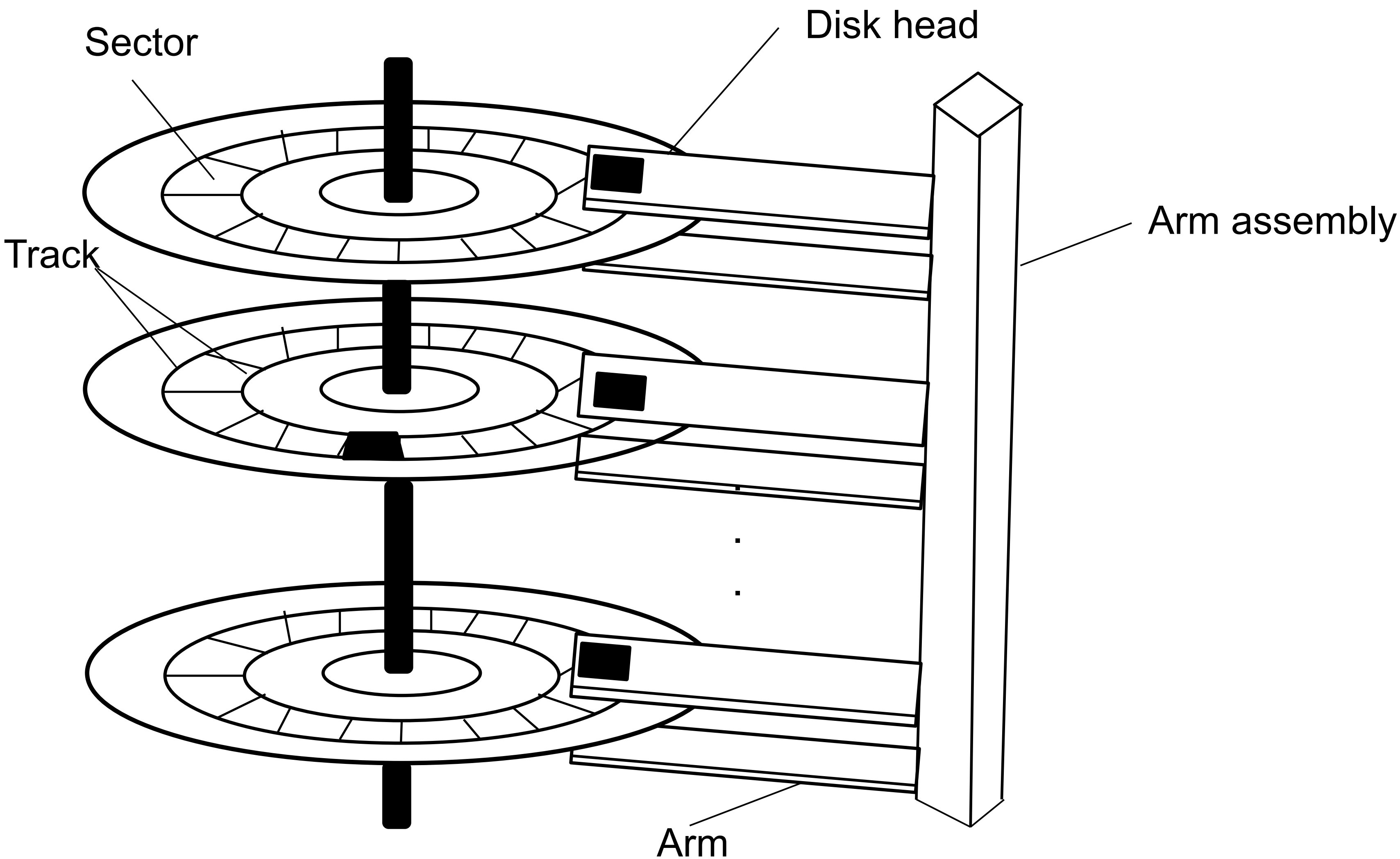
Magnetic Disk



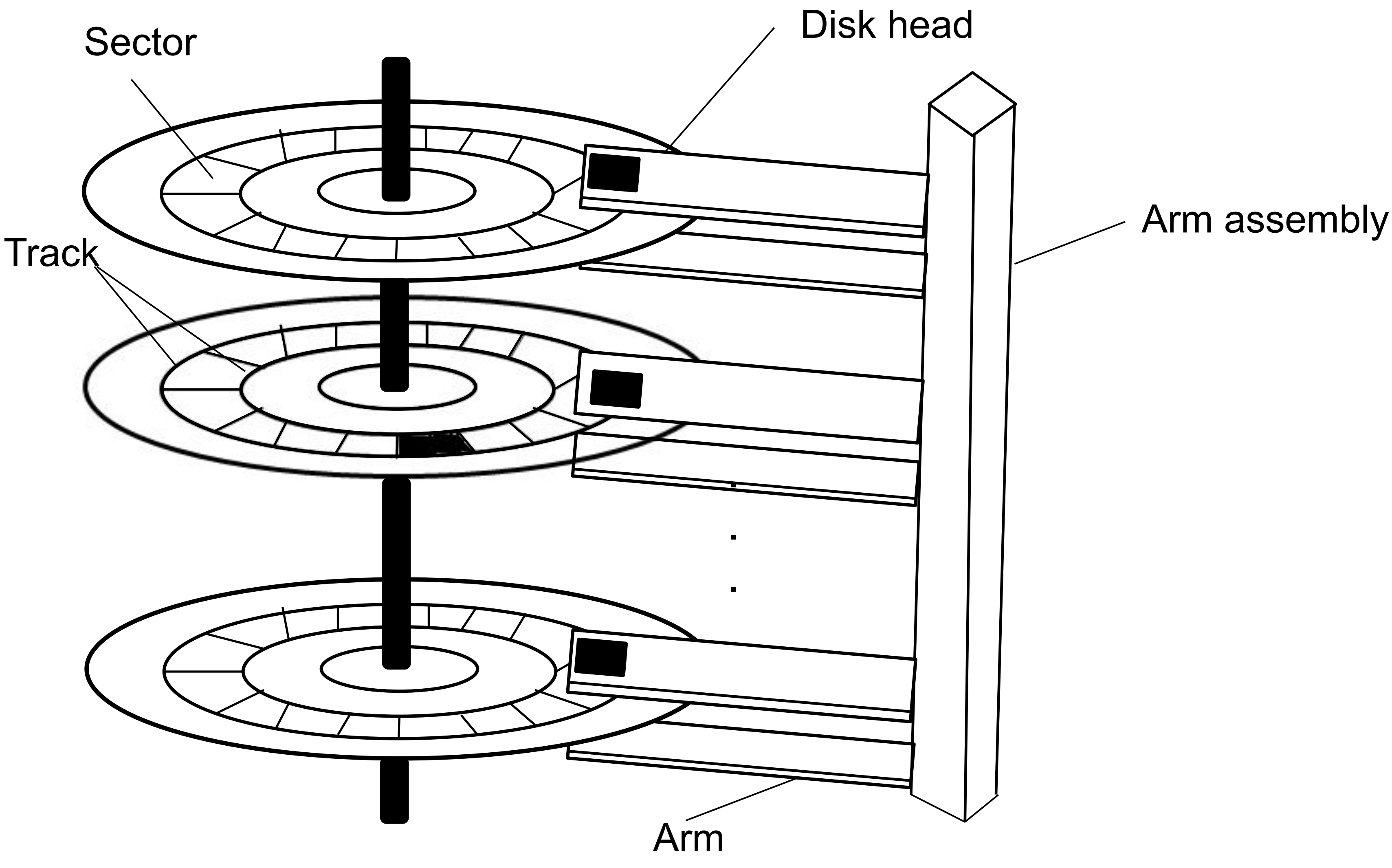
Magnetic Disk



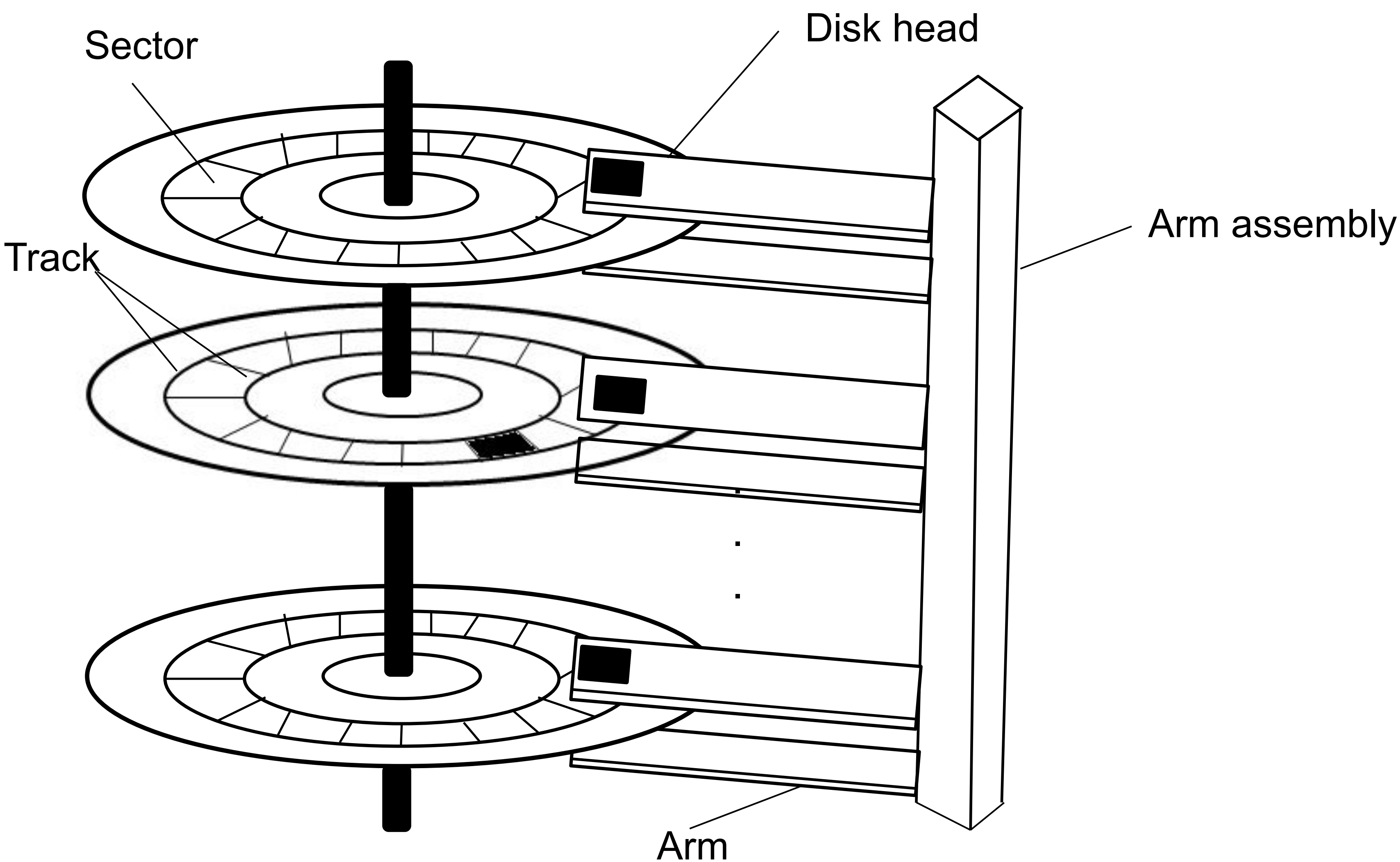
Magnetic Disk



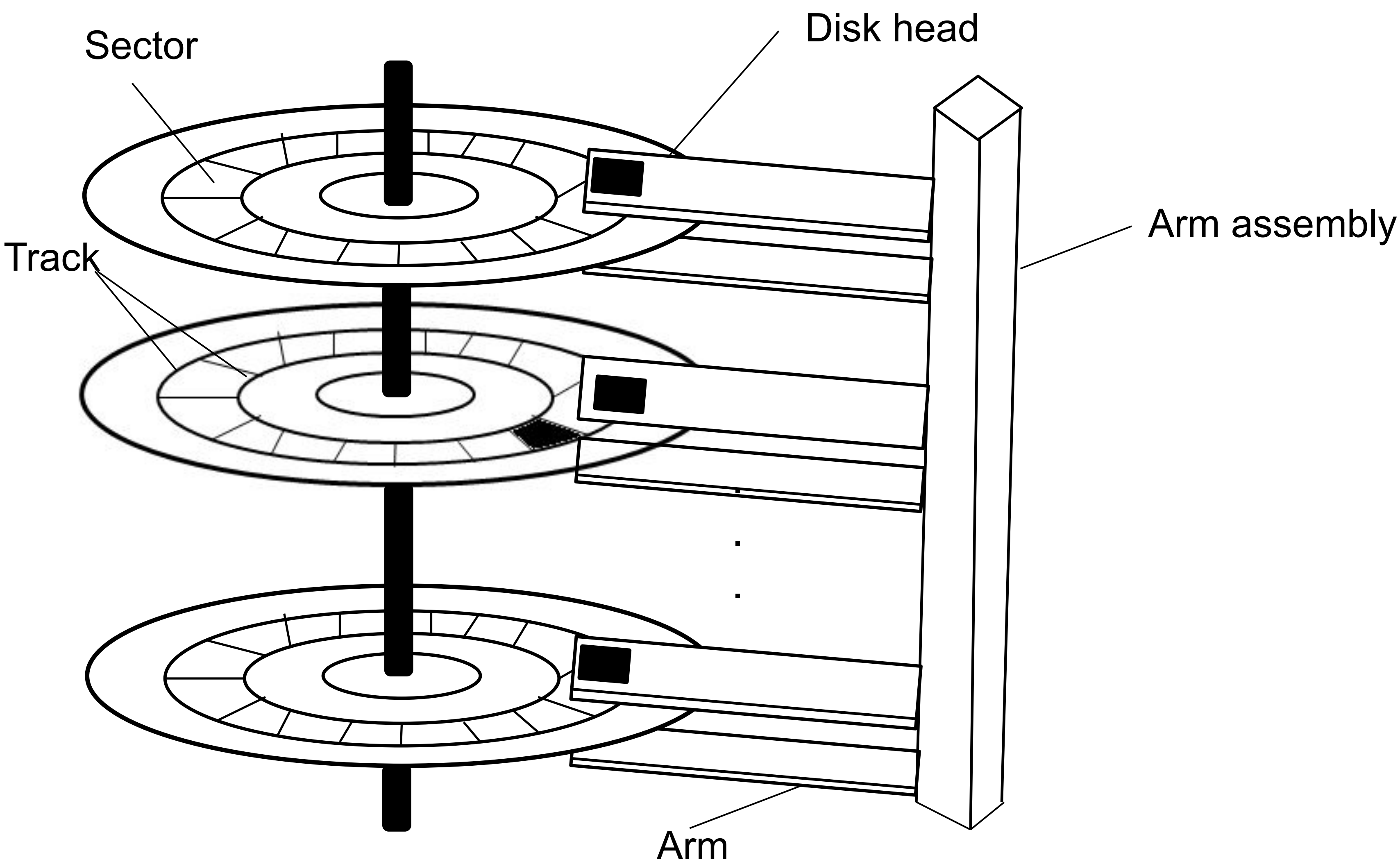
Magnetic Disk



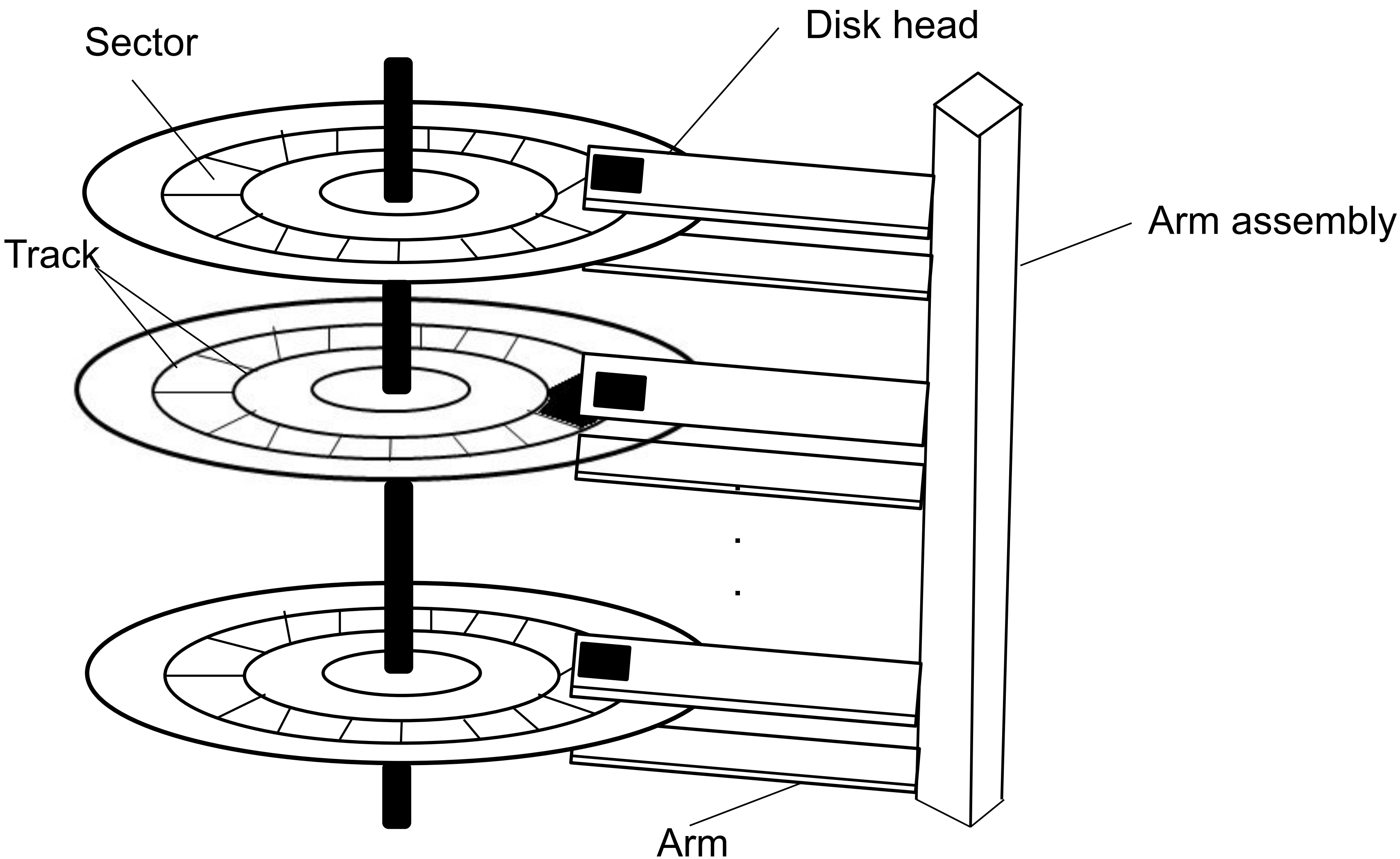
Magnetic Disk



Magnetic Disk



Magnetic Disk



Rotational Latency and Seek time

Seek time:
The time required to move the disk arm to a particular track is called Seek time.
Rotational Latency:
The time required to rotate the desire sector under the disk head is called Rotational Latency.

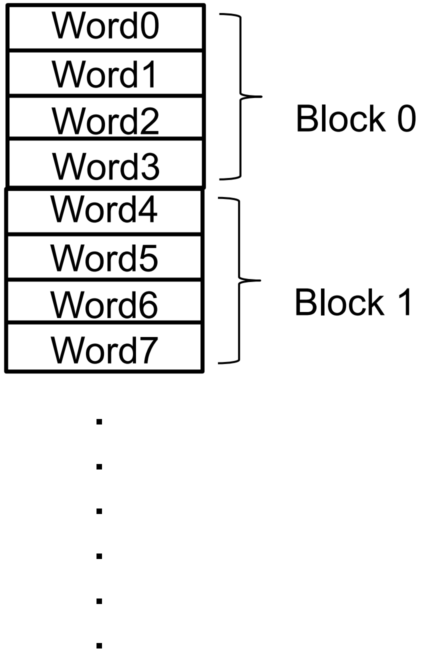
Positioning time = Seek time + Rotational Latency

A disk drive has 20 sectors/track, 4000 bytes/Sector, 8 surfaces all together. Outer diameter of the disk is 12 cm and inner diameter is 4 cm. Inter-track space is 0.1 mm. What is the no. of tracks, storage capacity of the disk drive and data transfer rate from each surface? The disk rotates at 3600 rpm.

No. of sectors in each track =20
Capacity of each sector = 4000 bytes
No. of surfaces = 8
Outer diameter of the disk = 12 cm
Inner diameter = 4 cm
Inter-track space = 0.1 mm
So, total width of track =(12-4)/2 = 4cm
No. of tracks in each surface = (4 X10)/0.1 = 400
The storage capacity of disk drive = No. of surfaces x No. of tracks in each surface x No. of sectors in each track x capacity of each sector
= 8 x 400 x 20 x 4000 bytes
= 256000000 bytes
= 244.14 MB
Rotational speed = 3600 rpm
No. of rotation in 1 sec = 60
Each rotation data transfer = 20 x 4000 bytes = 80000 bytes
= 80000 x 60 bytes / sec = 4.578 MB / sec

Thank You

Block size is 4 byte



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